

Amendments to the claims:

The listing of claims below replaces all previous versions of the claims in this application.

- [c1] (Currently Amended) An apparatus for measuring formation resistivity through a conductive pipe in a wellbore, comprising:
a sonde adapted to be moved through the wellbore;
a plurality of voltage measurement electrodes disposed on the sonde at spaced apart locations, the voltage electrodes adapted to make electrical contact with the pipe;
at least one current source electrode disposed on the sonde, the current source electrode adapted to make contact with the pipe; ~~and~~
a digital voltage measuring circuit controllably coupled to selected ones of the voltage measurement electrodes[.]; and
a current return electrode coupled to the pipe proximate the Earth's surface and a current return electrode disposed proximate the Earth's surface at a selected lateral distance from the current return electrode coupled to the pipe, and a switch to select a return path for measuring current from the current source electrode to the selected one of the electrode coupled to the top of the pipe and the electrode disposed at the selected lateral distance from the pipe.
- [c2] (Original) The apparatus of claim 1 wherein the digital voltage measuring circuit comprises of at least a twenty four bit resolution analog to digital converter.
- [c3] (Original) The apparatus of claim 2 wherein the analog to digital converter has a sampling rate of at least one thousand times a frequency of electrical current used to energize the at least one current source electrode.
- [c4] (Original) The apparatus of claim 1 further comprising a digitally synthesized current source coupled to the at least one current source electrode.
- [c5] (Original) The apparatus of claim 4 wherein the current source is adapted to generate switched direct current.

- [c6] (Original) The apparatus of claim 4 wherein the current source is adapted to generate switched direct current having less than a one hundred percent duty cycle.
- [c7] (Original) The apparatus of claim 4 wherein the current source is adapted to generate alternating current having a selected frequency and waveform.
- [c8] (Original) The apparatus of claim 4 wherein the current source is adapted to generate a pseudo random binary sequence.
- [c9] (Original) The apparatus of claim 1 further comprising at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde.
- [c10] (Original) The apparatus of claim 1 wherein the digital voltage measuring circuit is adapted to determine a direct current bias extant on the voltage measurement electrodes by operating substantially continuously.
- [c11] (Original) The apparatus of claim 1 further comprising:
at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde; and
a switch adapted to selectively connect selected ones of the electrodes to the focusing current source and to the digital voltage measuring circuit.
- [c12] (Original) The apparatus of claim 11 further comprising a processor coupled to the switch, the processor adapted to operate the switch to select which of the electrodes is coupled to the digital voltage measuring circuit, which of the electrodes is coupled to a measuring current source and which of the electrodes is coupled to the focusing current source.

[c13] (Original) The apparatus of claim 12 wherein the processor is adapted to select respective electrode connections by interpretation of command signals transmitted to the apparatus from a control unit disposed at the Earth's surface.

[c14] (Original) The apparatus of claim 12 wherein the processor is adapted to select respective electrode connections based on measured voltage drops across at least two of the electrodes.

[c15] Canceled

[c16] (Currently Amended) The apparatus of claim 1 further comprising a controller ~~first switch~~ operatively coupled between the plurality of voltage measurement electrodes, the current source electrode and the digital voltage measuring circuit, ~~and a second switch operatively coupled between the plurality of voltage measurement electrodes, the current source electrode and a source of measuring current, the first and second switches~~ the controller operable to connect selected ones of the plurality of voltage measurement electrodes and the current source electrode between the digital voltage measuring circuit and the current source so as to make measurements of voltage drop representing at least one of selected lateral depths of investigation and selected axial resolution.

[c17] (Canceled)

[c18] (Currently Amended) The apparatus of claim ~~17~~ 16 wherein the controller comprises programming for automatic operation of the first and second switches according to a predetermined sequence.

[c19] (Currently Amended) The apparatus of claim ~~17~~ 16 wherein the controller is adapted to detect commands transmitted from the Earth's surface for reprogramming the operation of the first and second switches.

[c20] Canceled

[c21] Canceled

[c22] Canceled

[c23] Canceled

[c24] Canceled

[c25] Canceled

[c26] Canceled

[c27] Canceled

[c28] Canceled

[c29] Canceled

[c30] Canceled

[c31] Canceled

[c32] Canceled

[c33] Canceled

[c34] Canceled

[c35] Canceled

[c36] Canceled

[c37] Canceled

[c38] (New) An apparatus for measuring formation resistivity through a conductive pipe in a wellbore, comprising:
a sonde adapted to be moved through the wellbore;

a plurality of voltage measurement electrodes disposed on the sonde at spaced apart locations, the voltage electrodes adapted to make electrical contact with the pipe;
at least one current source electrode disposed on the sonde, the current source electrode adapted to make contact with the pipe;
a digital voltage measuring circuit controllably coupled to selected ones of the voltage measurement electrodes; and
at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde.

- [c39] (New) The apparatus of claim 38 wherein the digital voltage measuring circuit comprises of at least a twenty four bit resolution analog to digital converter.
- [c40] (New) The apparatus of claim 39 wherein the analog to digital converter has a sampling rate of at least one thousand times a frequency of electrical current used to energize the at least one current source electrode.
- [c41] (New) The apparatus of claim 38 further comprising a digitally synthesized current source coupled to the at least one current source electrode.
- [c42] (New) The apparatus of claim 41 wherein the current source is adapted to generate switched direct current.
- [c43] (New) The apparatus of claim 41 wherein the current source is adapted to generate switched direct current having less than a one hundred percent duty cycle.
- [c44] (New) The apparatus of claim 41 wherein the current source is adapted to generate alternating current having a selected frequency and waveform.
- [c45] (New) The apparatus of claim 41 wherein the current source is adapted to generate a pseudo random binary sequence.

- [c46]** (New) The apparatus of claim 38 wherein the digital voltage measuring circuit is adapted to determine a direct current bias extant on the voltage measurement electrodes by operating substantially continuously.
- [c47]** (New) The apparatus of claim 38 further comprising:
at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde; and
a switch adapted to selectively connect selected ones of the electrodes to the focusing current source and to the digital voltage measuring circuit.
- [c48]** (New) The apparatus of claim 47 further comprising a processor coupled to the switch, the processor adapted to operate the switch to select which of the electrodes is coupled to the digital voltage measuring circuit, which of the electrodes is coupled to a measuring current source and which of the electrodes is coupled to the focusing current source.
- [c49]** (New) The apparatus of claim 48 wherein the processor is adapted to select respective electrode connections by interpretation of command signals transmitted to the apparatus from a control unit disposed at the Earth's surface.
- [c50]** (New) The apparatus of claim 48 wherein the processor is adapted to select respective electrode connections based on measured voltage drops across at least two of the electrodes.
- [c51]** (New) The apparatus of claim 38 further comprising: a current return electrode coupled to the pipe proximate the Earth's surface and a current return electrode disposed proximate the Earth's surface at a selected lateral distance from the current return electrode coupled to the pipe, and a switch to select a return path for measuring current from the current source electrode to the selected one of the electrode at coupled to the top of the pipe and the electrode disposed at the selected lateral distance from the pipe.
- [c52]** (New) The apparatus of claim 38 further comprising a controller operatively coupled between the plurality of voltage measurement electrodes, the current source electrode and

the digital voltage measuring circuit, the controller operable to connect selected ones of the plurality of voltage measurement electrodes and the current source electrode between the digital voltage measuring circuit and the current source so as to make measurements of voltage drop representing at least one of selected lateral depths of investigation and selected axial resolution.

[c53] (New) The apparatus of claim 52 wherein the controller comprises programming for automatic operation of the first and second switches according to a predetermined sequence.

[c54] (New) The apparatus of claim 52 wherein the controller is adapted to detect commands transmitted from the Earth's surface for reprogramming the operation of the first and second switches.

[c55] (New) An apparatus for measuring formation resistivity through a conductive pipe in a wellbore, comprising:

a sonde adapted to be moved through the wellbore;

a plurality of voltage measurement electrodes disposed on the sonde at spaced apart locations, the voltage electrodes adapted to make electrical contact with the pipe;

at least one current source electrode disposed on the sonde, the current source electrode adapted to make contact with the pipe;

a digital voltage measuring circuit controllably coupled to selected ones of the voltage measurement electrodes, the digital voltage measuring circuit including an analog to digital converter having at least twenty-four bit resolution and a sampling rate of at least one thousand times a frequency of electrical current used to energize the at least one current source electrode.

[c56] (New) The apparatus of claim 55 further comprising at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde.

- [c57] (New) The apparatus of claim 55 further comprising a digitally synthesized current source coupled to the at least one current source electrode.
- [c58] (New) The apparatus of claim 57 wherein the current source is adapted to generate switched direct current.
- [c59] (New) The apparatus of claim 57 wherein the current source is adapted to generate switched direct current having less than a one hundred percent duty cycle.
- [c60] (New) The apparatus of claim 57 wherein the current source is adapted to generate alternating current having a selected frequency and waveform.
- [c61] (New) The apparatus of claim 57 wherein the current source is adapted to generate a pseudo random binary sequence.
- [c62] (New) The apparatus of claim 55 wherein the digital voltage measuring circuit is adapted to determine a direct current bias extant on the voltage measurement electrodes by operating substantially continuously.
- [c63] (New) The apparatus of claim 55 further comprising:
at least one focusing current source controllable to maintain a selected voltage drop across a pair of reference potential electrodes, the focusing current source electrically coupled to selected electrodes on the sonde; and
a switch adapted to selectively connect selected ones of the electrodes to the focusing current source and to the digital voltage measuring circuit.
- [c64] (New) The apparatus of claim 63 further comprising a processor coupled to the switch, the processor adapted to operate the switch to select which of the electrodes is coupled to the digital voltage measuring circuit, which of the electrodes is coupled to a measuring current source and which of the electrodes is coupled to the focusing current source.

- [c65]** (New) The apparatus of claim 64 wherein the processor is adapted to select respective electrode connections by interpretation of command signals transmitted to the apparatus from a control unit disposed at the Earth's surface.
- [c66]** (New) The apparatus of claim 64 wherein the processor is adapted to select respective electrode connections based on measured voltage drops across at least two of the electrodes.
- [c67]** (New) The apparatus of claim 55 further comprising: a current return electrode coupled to the pipe proximate the Earth's surface and a current return electrode disposed proximate the Earth's surface at a selected lateral distance from the current return electrode coupled to the pipe, and a switch to select a return path for measuring current from the current source electrode to the selected one of the electrode at coupled to the top of the pipe and the electrode disposed at the selected lateral distance from the pipe.
- [c68]** (New) The apparatus of claim 55 further comprising a controller operatively coupled between the plurality of voltage measurement electrodes, the current source electrode and the digital voltage measuring circuit, the controller operable to connect selected ones of the plurality of voltage measurement electrodes and the current source electrode between the digital voltage measuring circuit and the current source so as to make measurements of voltage drop representing at least one of selected lateral depths of investigation and selected axial resolution.
- [c69]** (New) The apparatus of claim 68 wherein the controller comprises programming for automatic operation of the first and second switches according to a predetermined sequence.
- [c70]** (New) The apparatus of claim 68 wherein the controller is adapted to detect commands transmitted from the Earth's surface for reprogramming the operation of the first and second switches.